DOCUMENT RESUME

ED 363 268 IR 016 254

AUTHOR Litchfield, Brenda C.
TITLE Design Factors in Multimedia Environments: Research Findings and Implications for Instructional Design.
PUB DATE 12 Apr 93
NOTE 18p.; Paper presented at the Annual Meeting of the American Educational Research Association (Atlanta, GA, April 12-16, 1993).
PUB TYPE Information Analyses (070) -- Reports - Evaluative/Feasibility (142) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Computer Assisted Instruction; *Computer Software Development; Cooperative Learning; *Courseware; Educational Theories; Elementary Secondary Education; Epistemology; Higher Education; *Hypermedia; *Instructional Design; Interactive Video; *Learner Controlled Instruction; Literature Reviews; *Multimedia Instruction
IDENTIFIERS *Multimedia Materials

ABSTRACT

Current literature pertaining to multimedia programs is reviewed and discussed as it relates to the design and development of instructional programs. Most of the literature reviewed covers the last 4 years. Major areas discussed include: (1) instructional (instructional strategies and cooperative learning); (2) branching (navigation and learner control); (3) affective (learning styles and motivation); and (4) media (interactive videodisc, hypermedia, and hypertext). The review of the literature suggests that good instructional design is good instructional design regardless of the platform. Proven methods of increasing knowledge must not be ignored in the design of multimedia approaches. Cooperative learning is an effective and efficient way to maximize the number of systems in many learning situations. Navigation and learner control provide branching options for learners, and knowledge maps or hypermaps appear effective for guiding learners. With so many variables, multimedia programs can be perfect solutions or perfect nightmares for designers and learners. Multimedia programs must be based on sound epistemological theory that is alert to refinement and change. One tables lists citations for each design factor. (Contains 98 references.) (SLD)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 363 268

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Design Factors in Multimedia Environments: Research Findings and Implications for Instructional Design

Brenda C. Litchfield
313 ILB
University of South Alabama
Mobile, AL 36688
205-460-6202

AERA 1993
Atlanta, GA

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Brenda C. Litchfield

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Design Factors in Multimedia Environments: Research Findings and Implications for Instructional Design

INTRODUCTION

The number of electronic instructional programs is increasing at a rapid rate. When computer-based instruction (CBI) entered the educational scene years ago there were numerous media comparison studies. These continued until it was agreed that this type of study was not really telling us what we needed to know about the instructional value of CBI. Research then moved into the comparison of various features of different CBI programs. This still a valid area of research that is producing some interesting and valuable results.

Now enters multimedia: interactive video, CD-ROM, DVI, CD-I, hypermedia, hypertext, and hyperdocuments. Don't forget expert systems, teleconferencing, and virtual reality. Definitions abound for each of these programs and it is sometimes difficult to sort out the features and capabilities of each. A "hypermedia" search turns up "see hypertext." (Nielsen, 1990). When looking up "multimedia" in some texts, "see hypermedia" is given (Berk & Devlin, 1991; Reeves, 1993). Nelson contends that his definition of hypertext has always included multimedia (Berk, 1991). So what do we call all this?

Multimedia and hypermedia are two of the most overused terms in today's computer vernacular (Picher, 1991). Any number of programs are touted as multimedia or hypermedia by simply including visuals, text, and/or some color. There does not seems to be standard agreement regarding the components of each of these programs.When is multimedia actually hypermedia? Is IVD always multimedia? Does hypermedia include hypertext?

In her introductory chapter, Making Sense of Multimedia, Gayeski (1993, p. 4) offers a definition of multimedia : " ..a class of computer-driven interactive communication systems which create, store, transmit, and retrieve textual, graphic, and auditory networks of information." Included as multimedia are the programs mentioned above, plus several others. In addition, she specifies that hypertext is software consisting of networks of related text files that can be accessed by icons or search strategies. Hypermedia add graphics, audio files, and/or video clips. The amount of navigation allowed through programs is the primary classification factor. By this definition then, an interactive videodisc program could probably not be a hypermedia program unless it was a level III IVD program.

Although the whole idea of a hypermedia/hypertext environment is not new (Bush, 1945; Nelson, 1967), the sophistication (and simplification) of software and hardware allow easy access and manipulation of these programs. Hypercard essentially started the current proliferation of hyper-environments because it is easy to learn and use (Bowers & Tsai, 1990). Without the navigational features and structure requiring the learner to search and react, may multimedia programs remain "click and see" programs. Hypermedia provides the opportunity for multimedia to be raised to a higher level of interactivity.

The purpose of this paper is to review current research and literature of multimedia programs and to discuss their findings as they relate to the design and development of instructional programs. Because this area of research is relatively new and the rate of development in the the field of multimedia is changing so rapidly, the majority of literature reviewed covers mainly the past four years (1989-1993). Findings with CBI (current and older) are discussed where appropriate because of features that apply to multimedia environments.

Narrowing down the number of design features to review was not an easy task. Obviously, some areas are not included. The studies included are not conclusive and most raise more questions than they answer. This means there is a great deal more to investigate in the area of multimedia. Implications for designers of multimedia programs will be discussed throughout each topic and a chart (See Table 1.) summarizing each study is included.

The major areas discussed are the following:

- Instructional
  - instructional strategies
  - cooperative learning
- Branching
  - navigation
  - learner control
- Affective
  - learning styles
  - motivation
- Media
  - interactive videodisc
  - hypermedia
  - hypertext

INSTRUCTIONAL

The proliferation of multimedia instructional programs has produced a variety of approaches and examples of instructional strategies. While some programs identify specific theories as a basis for their design, many programs are not designed around any particular theory or approach. Many programs are simply termed as interactive or hypermedia. What this actually means can vary considerably. This discussion will focus on instructional strategies designed to encourage higher order cognitive processing and will provide examples of three

complex programs. Cooperative learning as a method for implementing instructional strategies will be examined and specific design recommendations for multimedia programs included.

Instructional Strategies

The instructional strategy of a program should be determined by the intended learning outcome. This is not always what happens. It is becoming easier and easier to design and develop multimedia programs these days and we are seeing quite a difference in the quality of programs. Some organizations are "producing videodiscs" that are no more than a collection of visuals, yet they proudly announce they are in the multimedia instruction business. So, just what does it take to design an instructionally sound multimedia program?

Again, intended learning outcomes are a defining factor in this aspect of design. With the current focus in education being on increasing students' problem solving, critical thinking, and decision making skills (Litchfield & Mattson, 1989), those programs focusing on these and similar outcomes are receiving attention.

The Cognition and Technology Group at Vanderbilt (CTGV) has been investigating anchored learning with an IVD mathematics program, Jasper Woodbury Problem Solving Series (1992a;1992b). This type of generative learning engages students in active rather than passive learning activities. They are involved with the program and are drawn in to situations where they are part of the problem solving process. The anchoring involves posing problems that are familiar to students and are meaningful. The CTGV has found that students using Jasper improved in basic math concepts, solving word problems (various levels of complexity), planning problems, and showed less math anxiety. Teachers were overwhelmingly positive about the program.

As a result of declining scores and lack of understanding regarding basic science processes by students in this country, in 1987 the National Science Foundation awarded eight large development grants (Litchfield, 1990). The largest among these was ScienceVision at Florida State University. This IVD project used an inquiry-based strategy which enabled students to actively participate in the investigation, experimentation, and resolution of scientific problems. Each problem was developed in a context that was meaningful and relevant to students so as to engage them in the specifics of the program. Research shows that students using ScienceVision score higher on attitude and achievement measures, have little difficulty navigating, use multiple data points when solving problems, and successfully transfer what they learned to real-life situations (Tobin & Dawson, 1992).

Three other exemplary IVD programs are the Mimi series and Palenque developed by Bank Street College. These programs provide students with an exploratory learning environment where they explore situations for the purpose of information seeking and decision making to solve problems presented to them (Wilson, 1987). Students were provided with a variety of information sources and participated in a high degree of interactivity. Students were highly motivated to work with the program because of the inclusion of games.

Not all instructional strategies are as complex as the examples above. Context appears to be an important part of instructional strategies in multimedia programs. Using anchored instruction in a video-based program, Sherwood, Kinzer & Carrick (1987) found that students using the context supplied in the video were able to transfer science concepts much more easily than those receiving instruction not anchored in a context. Context is also helpful when designing multimedia fiction (Gay, 1991) and developing storylines for CBT (Wilson, 1991).

Generative, inquiry-based, problem solving instructional strategies tend to produce positive results for students using multimedia programs--especially when they work cooperatively. They discuss, reason, and evaluate situations and ideas more fully than in circumstances where they work individually. Students are involved in their learning rather than being passive sponges expected to absorb information. Instructional strategies must be carefully designed and developed in order for multimedia programs to be effective and efficient for students. Also connected to the concern of effectiveness and efficiency is how students are grouped at the computer with the program. Cooperative learning is a logical answer to the problem of limited resources existing in many classrooms.

Cooperative Learning with Multimedia

Cooperative learning is one of the most extensively studied and researched of all instructional methods (Slavin, 1991). Researchers agree that cooperative learning can produce positive results on achievement (Johnson, Maruyama, Johnson, Nelson, Skon, 1981; Slavin, 1991) and affective benefits such as increase in attitude and self-esteem (Hoelscher, 1990; Noell & Carnine, 1989; Simsek & Tsai, 1992; Rysavy & Sales, 1991; Slavin, 1991). The problem is that there does not seem to agreement on the conditions that facilitate these results.

Ability grouping of students in cooperative learning groups has produced mixed results with both positive and negative results for both homogeneous, heterogeneous, and mixed groups. Some factors affecting results may be reward structures (Klein, Erchul & Pridemore, 1993), gender differences (Rysavy & Sales, 1991), or age (Tudge, 1991). Generally, homogeneous grouping is effective for high-ability students but not for low-ability students (Johnson & Johnson, 1986).

Hooper (1992) suggests that research should focus on several factors. Feedback timing should be investigated because the standard immediate feedback setup of most CBI programs may not be effective for groups of students who need time to discuss and arrive at solutions or conclusions. Group interaction patterns could be facilitated through the use of interaction training and instruction scripting given to students before and during use of programs. Finally, he suggests examining grouping based on learner characteristics (gender, ability, popularity).

Multimedia programs and CBI present a new set of concerns for cooperative learning. Most CBI programs are designed to take advantage of having students work individually. This is one of the main selling points. Most classrooms, however, are limited to one or two computers so students are assigned to work in groups. This instructional adjustment necessitated by lack of equipment puts a different focus on cooperative learning. Rather than continuing to conduct numerous studies on ability grouping, the cooperative learning research focus needs to shift to specific design factors that should be included in multimedia to create positive cognitive and affective results.

Software developers can be instrumental in increasing the success with cooperative learning in multimedia programs by being cognizant of the essential components and designing programs incorporating these features. Recommendations from Rysavy & Sales, (1991) include tutorial activities for collaborative skills, pauses in the program to allow students to discuss points, program reminders for students to monitor their progress, and group rewards (computer generated certificates, coupons). In addition, teachers require information and methods to successfully implement cooperative learning with multimedia programs.

To continue to apply individualized programs with their specific design characteristics to groups of students may keep students from accomplishing as much as they are capable of and add to learning frustration. Even though many multimedia programs encourage cooperative learning groups, their internal design and directions for use often do not include how to implement this type of instructional strategy.

Designers of multimedia should be well versed in cooperative learning methods and be able to apply them to instructional program design. This includes the overall focus for the activities students are engaged in and in the printed materials (student and teacher manuals) accompanying the program.

AFFECTIVE

The way students approach, interact, and persevere with a multimedia program is directly related to how they perceive the task and the situation. This perception is influenced by their particular learning style and their level of motivation. Both factors can ultimately increase or decrease achievement, time-on-task, selection options, and attitude. This section will examine the relationship between learning styles, motivation, and multimedia programs.

Learning Styles

Learning styles are the various methods individuals have for perceiving and processing information while reacting to their environment. Several theories (Dunn & Dunn, 1978; Gregorc, 1984; Kolb, 1981; McCarthy, 1980) of learning styles are applicable to the design of multimedia programs. Very little research has been done on interactions between learning styles and instructional design or presentation (Jonassen, 1988). Research specifically addressing multimedia programs and learning styles is almost nonexistent.

In contrast to CBI, multimedia programs can offer a wider range of information presentation and instructional strategies that more closely match various learning styles. Learning styles are generally definable with individuals falling into one or more categories of a particular theory. Once an individual's style is determined, then instructional programs using a particular approach can be prescribed. Each of the above theories contains specific components that are translatable into design and presentation features.

The results of a CBI study by Cordell (1991) found that learning style groups differed with respect to the instructional design of the program. Individuals classified as assimilator or diverger (Kolb, 1981) performed better with the branching CBI than those classified as accommodater or converger. The way individuals perceived and processed information was affected by how the program was designed.

In an IVD study by Carlson (1991) where material was presented inductively or deductively, achievement for observational skills increased when learning style matched the instructional style. Learning style was also exhibited in the preference for cooperative learning. Thus matching learning style with the design of instruction was important for both achievement and positive attitudes.

Students in a computer applications course were classified using Gregorc's (1984) learning style inventory where they were classified as abstract random, abstract sequential, concrete random, or concrete sequential. Students then participated in the course activities which consisted of projects and exams. Highest scores were obtained by abstract sequentials and lowest scores were obtained by abstract randoms (Davidson, Savenye & Orr, 1992). Findings indicate that computer applications courses with structured, sequential formats (BASIC) do not

favor random thinkers. Instruction might include programs such as Hypercard or LinkWay to help random thinkers develop familiarity with programming.

In a hypermedia environment Yung & Lee (1992) found that achievement scores, time on task, and selection frequency in viewing embedded information were affected by the interaction of learning styles and instructional strategy. The advisory group performed better than the non advisory group. Active learners chose to spend more time on task, view embedded information more often, and scored higher on the achievement test.

Learning styles are evident in the ways students exhibit what they have learned and how much they have learned. Multimedia programs deliver information through multiple media so as students exhibit how they learn, they should be encouraged to use a variety of media. This can be accomplished by providing options for learner-generated feedback rather than students always being the recipients of program-generated feedback (Litchfield, 1993).

The paucity of studies in this area indicates that much work is needed before we can know which design factors incorporating learning style aspects increase achievement, attitude, and motivation in multimedia programs. Designers should include a variety of methods in programs to account for different learning styles. Perhaps alternate pathways through a lesson could be selected depending on learner preference. This would allow students who may get confused by excessive branching to travel a more predetermined path thus decreasing frustration.

Material could be presented in text, visuals, and sound to accommodate students with differing modalities. Visuals on screen could be accompanied by text in a manual. Audio could paraphrase or read text verbatim. Students could choose one or all of these features depending upon how they learn best. Knowledge of learning styles can afford designers with a wide range of instructional approaches that can increase students' achievement and motivation.

Motivation

It is generally agreed that when using CBI or multimedia programs, motivation increases when students work cooperatively (Johnson & Johnson, 1986; Rysavy & Sales, 1991) have *some* choice in their pathways through a lesson/activity (Kinzie, 1991; Lanza & Roselli,1991; Ross & Morrison, 1988), and the user-interface design is easy to follow (Trumbull, Gay & Mazur, 1992; Gray, 1987; Marquez & Lehman, 1992). These factors have been studied in isolation and as components of many other studies and findings are fairly consistent.

Building motivation into multimedia programs encompasses the integration of many factors. Assuming no fear of computers, students seem to be inherently motivated to interact with electronic programs. This is often attributed to the novelty of this form of instruction because the majority of students do not use computers and multimedia programs on a regular basis. So motivation is there for now. What happens as students at all levels become more familiar with multimedia and it becomes more of a standard mode of instruction? The question of motivation -- gaining and maintaining it -- becomes more important. Programs in the future cannot rely on their novelty of use but rather on their uniqueness of instructional strategies.

The ARCS (attention, relevance, confidence, satisfaction) motivation model (Keller, 1983) is especially suited for design of CBI and multimedia programs (Keller & Suzuki, 1988). Each of the four components of the model contains several specific guidelines for increasing a students' motivation to learn. These guidelines are easily incorporated into the design of multimedia programs and should be carefully considered before, during, and after actual program development.

Presently, students have high attention simply as a function of using a multimedia program. It is often a new method of learning and students look forward to using it with anticipation. Designers may be safe here for a *very* short while. In the future they will need to think about how to gain and maintain both aural and visual attention.

Relevance is accomplished by including familiar language and examples. This can be accounted for in the design. The other part of relevance is a bit more difficult. Relevance is considered the "so what?" of a task. Students want to know, "Why do we have to do this?", "How will I use this outside this room?", "What good is this information?" This is not so easy to answer in a multimedia program. In many instances, the relevance of instruction may have to appear as specific statements informing the learner of the utility of the skill or knowledge.

Confidence can be incorporated in multimedia programs by informing the learner of goals and objectives and providing learner frequent, early opportunities for success. Embedded questions, scoring, self-checks, and practice questions are good methods.

Being able to transfer the skills or knowledge to a real-life situation, and do it soon, help to build Satisfaction. Multimedia programs should include suggestions for applying skills or knowledge in places other than the classroom. Manuals accompanying programs should include additional practice and reinforcement.

Also important for affecting learner knowledge and attitudes is reception. Flagg (1990) lists attention, appeal and excitement as the three component of reception. Attention is achieved through audio and visual

features. Appeal involves degrees of likableness, interest, personal relevance, familiarity, credibility, and acceptability. Excitement is measured through overt participation and physiological arousal.

Motivation, for the learner, is the initial determining factor influencing everything in a learning event (Keller & Burkman, 1993). It would follow then that designers should be particularly diligent and deliberate to include motivational components throughout multimedia programs. This is becoming more critical as students become more familiar with this type of instruction.

BRANCHING

Perhaps the most visible and variable features in multimedia programs are branching structures. Movement through a program is referred to as navigation. It is accomplished by interface designs using a series of choices appearing in the form of menu selections, icons, buttons, or screen hot spots. The degree of navigational choice is set by designers and incorporated as varying amounts of program and/or learner control. Navigation and learner control are closely related, however the act of navigation itself can be considered a program feature while learner control (in the broadest sense) is not. Navigation will be discussed first as an entry into studies of learner control in CBI and multimedia programs.

Navigation and User Interface

There is a broadening gap between the capabilities of interactive computer systems and the ability of people to efficiently and effectively use these capabilities (Mueller, 1991). Often programs include difficult command languages, incomplete directions, dead ends with complex return procedures, inconsistent icon design or placement, crowded screens, inadequate timing, and insufficient feedback. Navigation is influenced by interaction languages, display devices, presentation modes, input devices, and ergonomics (Venezky & Osin, 1991). These combine to affect the interaction with a system or program. Psychological principles and learning theory can be employed in the design of each of these components of a program. Learners get frustrated when programs are designed without regard to research and tested methods. This is especially true for those new to a multimedia program. What navigational features can facilitate learning and increase motivation?

In Macintosh environments, the standard navigation tool is the icon. Placement of icons varies with each program developed and can be anywhere on a screen. Marquez and Lehman (1992) investigated the roles that gender, handedness, and mouse experience had on icon placement in a hypermedia program. No significant differences for preference were found for gender or handedness. Students with prior mouse experience had significant task performance differences.

In a study of menu design (Schuerman & Peck, 1991) three types of menus were used: pull-down, return-to-main-menu, and return-to-sub-menu. The investigators hypothesized that pull-down menus would encourage a more random access of the lessons in the program. Findings indicate, however, that pull-down menus did not encourage random access of instructional components and learners tended to spend a longer time inspecting menu options than the other two groups. This is important for designers because the pull-down menus are space saving and efficient when compared to other types of menus.

In learning concepts and simple rules, matrices such as the rational set generator (Dempsey, 1986; Driscoll and Tessmer, 1985) have been an effective navigation device for presenting interrogatory instances of examples and nonexamples of concepts. Properly sequenced, a matrix model provides for concept instances (and noninstances) which adequately fulfill the learning requirements of either successive or coordinate relationships. The computer adaptation of this model has proven effective in a number of studies with varied content.

Navigational aids are often essential for learners to keep from being lost in hyperspace. These aids can be grouped in logical patterns or visual metaphors. Trumbull, Gay & Mazur (1992) used a multimedia program, The Bughouse, to study students actual and perceived use of navigational and guidance tools. Four modes of navigation were used: index, guide, browse, or a mixture of all. Most students used the browse mode, followed by index, guide, then mixture. Students in the browse mode saw more, spent longer, and revisited more events than other groups. Indexers (highest GPA of all groups) were not as high in any area but felt they had seen almost everything in the program (they had not). Guiders made the greatest number of repeated visits,were not high in other areas and felt they had seen almost everything. Mixers (lowest GPA) were not sure they had seen all events even though they visited as many relevant events as the Guiders.

What are the implications for designers? Students should be aware of the structure and functions of multimedia programs before they use them. This should have an impact on their navigational behavior, although there is little research to support this idea (Jih & Reeves, 1992). They should be aware of what options are available. Understanding the interface should alleviate confusion and frustration experienced when lost in a program. Learners should receive instruction on how to navigate through a system along with a graphic display of

the overall structure of the program. Programs designed with graphic network maps that move (by icons or buttons) students to different locations would serve as program guidance and as a tool for navigation.

Learner Control

In multimedia programs, learner control is the amount of latitude a learner has over direction and depth of investigation. This degree of control can be preset by the program to afford the learner limited or total control. Studies of learner control in CBI have not been conclusive and for the most part have been negative (Ross & Morrison, 1988b).

While some learner control can be motivating to students, too much can be confusing (Azbell & Milheim, 1988; Okey & Jones, 1990). A review of studies on learner control in CBI finds that the learner is not always the best judge of the instruction needed for effective learning (Murphy & Davidson, 1991). For some learners learner control does not promote learning and they even choose to return to programs where content is program controlled (Kinzie & Sullivan, 1989). Low ability students are especially confused with high levels of learner control. They do not have the mental models and schema necessary to investigate a program efficiently and effectively.

Age of learners and expectations of instruction can also influence the amount of learner control needed in a program. Children's performance appears to decrease when given high degree of learner control in an IVD lesson although their motivation increased (Arnone & Grabowski, 1992; Morrison, Ross, & Baldwin, 1991). Elementary students tended selected fewer topics for study and chose less instructional support from the programs. For adults, a high degree of program control is neither understandable nor acceptable (Cooper, 1991; Gery, 1989) and highly motivated adults seem to prefer a greater degree of learner control over program control (Barnard, 1992; Lanza & Roselli, 1991) .

Different areas of research have varying effects on the impact of learner control in CBI (Friend & Cole, 1990). Studies have focused on numerous aspects such as preferences for instructional methods, sequencing, and the relationship of individual characteristics to control. Kinzie (1989) suggests three reasons for inconsistent benefits from learner control: a behaviorist rather than cognitive orientation, individual student differences, and discomfort and inexperience in exercising option controls.

So how much learner control is too much? When is it too little? The best results in learner controlled situations have come from those programs using advisement, specifically **adaptive advisement** (Johansen & Tennyson, 1983; Kinzie, 1991). Santiago & Okey (1992) found that adaptive advisement was beneficial to students in effectiveness, appeal, and efficiency. Students appeared to feel more confident with advisement because it helped them make choices related to amount of practice.

Programs with a high degree of learner control do not provide the majority of students (children and adults) with effective and efficient instruction. Reasons for this could be that learners do not have enough subject or program knowledge to make the most beneficial instructional choices. Many students are not familiar with pacing, sequencing of content, use of learning aids, and the amount of practice needed to master a topic or skill.

For instructional designers, learner control provides several considerations. Advisement has been shown to be effective and should be included in CBI and multimedia programs. Informing students of options based on performance can increase achievement and motivation. Because learners differ in their approaches to information retrieval, several search options should be included in programs. This will account for various learning styles and prior knowledge.

The question of perception of learner control is an important one. It is not that learners should be fooled into thinking they have more control that they do, however, some aspects of a program under their control can be those that have been shown to increase performance and motivation. Allowing learners to **select text density** and **problem themes** (Ross & Morrison, 1988a) can have a positive effect on both performance and the perception of learner control. The real challenge for designers and researchers is to find out what other factors fit into this perception-performance increase category.

MEDIA

Several research findings discussed up to this point have been conducted with CBI programs. This is because there is a lack of studies (in the areas chosen in this paper) relating directly to multimedia programs. Even so, findings from CBI help define the boundaries of design for multimedia programs and should be closely examined. This next section will review studies of interactive videodisc, hypermedia, and hypertext programs. Although there is considerable overlapping in the features of these programs, they will be treated primarily as separate approaches to research multimedia instruction. The main reason for this is the classification of each study as supplied by the investigators of the individual studies. The findings should be applicable to most multimedia programs.

Interactive Videodisc

When the term multimedia is mentioned, interactive videodisc (IVD) usually comes to mind. This form of instruction has been rapidly increasing over the past ten years. Used more extensively in business and industry training, it is now making its way into public schools and university classrooms. The literature on IVD is vast and conclusions have been generally positive, though based on inconsistent and contradictory findings. In a meta-analysis (63 studies) of a 10 year of review of achievement effects McNeil & Nelson (1991), found that as an instructional method it can be effective. It was also found that group instruction was favored and IVD was best when guided and structured rather than being entirely under the control of the learner. Another meta-analysis (24 studies) of IVD instruction by Fletcher (1990) applied in defense training, industry settings, and higher education found that IVD improved achievement for knowledge and performance outcomes. Interactive video disc programs are now routinely considered and used in defense training and education.

Four specific design factors for IVD deserve particular attention: interactivity, visuals, motivation, and learner control (Cronin & Cronin, 1992). The research on these factors and their subcategories provides some interesting guidelines for designers to consider and incorporate into IVD programs. Interactivity can be extremely misleading and variable. With IVD, the level of the disc (1, 2,or 3) is a determining factor in the degree of interactivity. (For purposes of this discussion, it is assumed that IVD programs are level 3.) Interactive videodisc is variable and must be assessed using specific criteria formulated prior to the design stage (Litchfield, 1990). The amount of interactivity determines the degree of participation the learner has in the program. In IVD it is important that the learner be actively involved in problem solving, decision making, and critical thinking. If there is no data creation or manipulation, variable determination, investigation, action, or inquiry made, the use of IVD as the platform should be examined.

The visual aspect of IVD is its greatest strength and can increase comprehension of the content (Burwell, 1991) especially for low achieving students (Barba & Armstrong, 1992). As with interactivity, visual characteristics can vary widely in duration from stills to video sequences. An interesting technique, hypervideo (Locatis, Charuhas & Banvard, 1990), is used primarily in programs emphazising visual information retrieval. Hypervideo condenses audiovisual information into small units and accelerates presentation time. Its usefulness depends on the topic presented and audience sophistication with rapid visuals.

Designers of IVD programs should pay particular attention to the amount of interactivity included in the program. It is this interactivity that can be used to introduce practice activities, embedded questions, decision points, and participation with the learning experience. Orienting and practice activities can familiarize students with programs and make it easier for them to understand the structure and nature of interactive video (Hannafin, Phillips & Tripp, 1986). Design of programs can be streamlined by designing each component of instruction separately then testing and integrating them as a unit (Litchfield, 1992). This process is useful for multiple disc programs using the same instructional strategy. It assures consistency across topics and activities especially when several designers are working on the same project.

Motivation and learner control findings for IVD design factors are similar to those discussed for CBI. Motivation should consider a range of components as described in the ARCS model (Keller, 1983). Learner control is best with advisement. Additional findings indicate that learner control is affected by learning style (Burwell, 1991). Field-dependant students had significantly higher recall scores with program control whereas field-independent students had significantly higher recall scores with learner control. Learner control should be moderately structured with more of a perception of control than actual control. In this perception, the aspects under control should be mainly those having shown to improve achievement, attitude, or motivation rather than those simply there for control's sake.

There seems to be a general positive effect for students working cooperatively with IVD programs. Cooperative learning increases discussion, cognitive processing, and social interaction. Essential components of cooperative learning need to be incorporated into the design of IVD programs. In addition, specific guidelines for implementing cooperative learning should be included in teacher/instructor materials.

Hypertext

Hypertext systems have been available for quite some time in the forms of dictionaries, encyclopedias, card catalogs, citation indexes, and any other form of concentrated information. The only difference today as opposed to 20 years ago is now systems can be linked electronically. Instead of walking to find a source, typing is the mode of retrieval. Hypertext has several advantages over hypermedia: performance, economy, ease of development, ability to run on less expensive and more equipment that is more universal and transportable (Berk, 1991). Technological features include nodes, links, browsers, searching and back-tracking (Tsai, 1988). Hypertext systems can be divided into four classes (Conklin, 1987): browsing systems, problem exploration tools, macro-literary systems, and general purpose hypertext.

The size, context, content, and associative capabilities of nodes and links in hypertext can vary considerably. A node can include a single concept or provide a point for complex integration of information. Hypertext has been compared to the human brain in the way information is accessed and associated (Jonassen, 1989). Nelson & Palumbo (1992) however, argue that the parallel between associative memory and hypertext is limited. When the brain associates, it places a value or degree of connection on the link. In this way the strength of association is realized. Currently, most hypertext systems do not incorporate this information. The resulting search through a hypertext system that does not include information about the strengths of associations can lead to cognitive overload for many individuals.

Many studies investigating use of hypertext environments have focused on the issue of cognitive overload, confusion, and "lost in hyperspace." Adults reading hypertext for the purpose of answering specific questions who used a depth first search were more successful than those using a breath first search (Gillingham, 1992). Also, more successful readers chose important hypertext nodes more often and read them longer than unsuccessful readers.

Information presented in associational forms such as multi-relational semantic maps appears to have advantages over more traditional presentations (Lambiotte, Dansereau, Cross, & Reynolds, 1989). Studies by Jonassen & Wang (1992) showed that depicting knowledge structures by using a graphic browser or by informing the learner of the explicit links during the program did not improve learning. When students created their own semantic network maps after browsing, structural knowledge improved significantly. Working with knowledge hypermaps and hypertext, Reynolds & Dansereau (1990) found satisfaction increased with hypermaps along with greater efficiency on measures of reference accuracy and time. In a related study Reynolds, Patterson, Skaggs & Dansereau (1991) found that students using hypermaps to learn statistics were less frustrated and confused than students using hypertext although performance differences on recall and reference tests were not significant. In contrary findings on the use of hypermaps, Stanton, Taylor & Tweedie (1992) found that the use of hypermaps as navigational aids resulted in poorer performance, less use of the system, lower perceived control, and poorer development of cognitive maps when compared to a condition with no map present.

Hypertext is an attractive retrieval medium that can provide almost limitless access to numerous forms of information. As hypertext programs proliferate and are more available for learners, it appears that designers should concentrate on the confusion factor associated with using a program. For novice users, hypertext can be a inefficient, ineffective, and even frustrating. Students may not even be cognizant of where they need to be, what is available, and how to make the best use of the information at hand. If they realize they need something they cannot locate then they can become confused. Cook (1991) suggests seven maxiums to alleviate the "lost in hyperspace" syndrome. Other solutions could be to help users find entry points into hypertext with a form of traditional search strategy already familiar to them such as limited vocabulary and search words and providing full-text searches (Binder, 1989). Hypermaps appear to offer learners additional guidance and grounding for learners throughout their searches.

In the past few years designers have been moving away from the linear programs encountered for so many years in CBI. Hypertext requires a non-sequential approach to design. As programs are perfected, perhaps there will be a measure of standardization where learners will be able to recognize search patterns so information retrieval becomes more precise.

Hypermedia

The last type of electronic instruction examined is hypermedia. Distinctions between hypermedia and hypertext are blurry and the terms are often used interchangeably. For purposes of this discussion, hypermedia is an extension of hypertext although the functional features depend on its intended use (Park, 1991). Text-based electronic programs are enhanced with video, stills, graphics, animation or a combination of all. This medium (or media) is designed using the same basic considerations as discussed in hypertext and interactive video (assuming level III). Because the designs of these hyper systems are similar, the problems learners encounter are similar. Confusion that may be encountered in hypertext programs can be increased using programs that are primarily visual based.

There is a small but growing body of literature addressing hypermedia in terms of learning theory (Ambrose, 1991). The associative nature of hypermedia provides numerous realms of study: program differences, student learning styles, navigation, and others. Major areas of research are access and linkage as relates to recall and retention of information. Investigating the differences in recall of information presented in a hypermedia or linear format, Nelson and Joyner (1990) found that students using the linear format had significantly better recall. Without text, which may be familiar, the links and nodes of a program may be difficult to discern for some learners. On the other hand, some learners may find it easier to navigate through programs and make decisions in a visual environment. Learning styles, modalities, and motivation are activated by different delivery mechanisms

available in multimedia programs. Learning can improve when there is significant conceptual and temporal overlap between the information presented in each modality (Hannafin & Hooper, 1993).

In a hypermedia study related to information seeking behaviors and motivation (Small & Grabowski, 1992), results showed that changes in motivation were greatest for males and students consistently used one (video with sound text and graphics) of three available formats. When given the choice in hypermedia, most students chose this presentation mode. This, however, does not guarantee that students are learning what they are supposed to learn from the experience.

Hypermedia systems can provide many of the characteristics that facilitate discovery and incidental learning. Students using hypermedia to learn languages were able to study language in a more comprehensive intercultural format that helped them examine their personal knowledge constructions (Gay & Mazur, 1989). In order to increase incidental learning it is important that learners receive instruction or information regarding their task before using a hypermedia system (Kinzie & Berdel, 1989). When learners of all ages were given objectives they showed the greatest amount of recall and incidental learning (Heller, 1990).

It is clear from the research in hyper systems that the majority of students needs guidance to benefit from these learning experiences. At least this is true today. As students become more sophisticated and competent in their use of hyper systems, problems with navigation, cognitive overload, and frustration will decrease. Patterns of links and methods of information access will be well established and part of students' educational repertoire. Until this time, researchers and designers are faced with many challenges.

SUMMARY

Regardless of specific design factors, learning seems to be affected more by relevant cognitive activity than by particular instructional systems (Hannafin & Hooper, 1993). In other words, good instructional design is good instructional design whatever the platform. Designers should not concentrate on what is needed to specifically design a particular multimedia program and neglect components good instruction. Even though multimedia programs present a new set of considerations, it is imperative that the proven methods of increasing knowledge be integrated.

Several features are vital to good design of multimedia programs. Instructional strategy forms the basis for approach and philosophy. As a strategy, cooperative learning is an effective and efficient way to maximize the limited number of systems in many learning situations. Affectively, students' learning styles and motivation are critical perceptual aspects of their educational environment. The variation in these areas necessitates incorporating multiple means for searching, accessing, and retrieving information.

Navigation and learner control provide branching options for learners. Too little is restrictive and too much can be confusing. Knowledge maps or hypermaps appear to be an effective method for guiding learners through the hypermaze in which they often find themselves. The primary media of electronic programs, IVD, hypertext , and hypermedia, are closely related and integrated. Throughout these programs the functions of navigation and learner control affect the cognitive, affective, and psychomotor domains of the learner. With so many variables, multimedia programs are perfect solutions or perfect nightmares for both designers and learners.

It has been suggested (Devlin, 1991) that standards be developed for multimedia hypermedia systems. Quality control of multimedia development projects also lacks standardization due to it infancy (Litchfield & Dempsey, 1991-92). The problem is that program development is complex and is occurring faster than standards development.

Research plays a critical role in the development of multimedia programs. We must consider how these innovations fit in with their intended environments (Gayeski, 1993). As more research is conducted in all areas related to hyper programs there will be more information available for refinement of programs. Careful integration of findings and design will allow the best match between the media and the learner. Improvement of design features based on learning theory and motivation is essential to the success of students using these various systems. Multimedia programs have the potential to facilitate higher-order thinking and increase learners' metacognition. This cannot happen through trial and error design and development. Programs must be based on sound epistomological theory that is ever alert for refinement and change.

Cooperative Learning

Hoelscher, K.J. (1990). Bridging the classroom and the real world: A videodisc implementation study at Harvard law school. *Journal of Computing in Higher Education, 2*(1), 32-77.

Hooper, S. (1992). Cooperative learning and computer-based instruction. *Educational Technology Research and Development, 40* (3), 21-38.

Johnson, D.W. & Johnson, R.T. (1986). Computer-assisted cooperative learning. *Educational Technology, 26*(2), 12-18.

Johnson, D.W., Maruyama, R., Johnson, R.T., Nelson, D. & Skon, L. (1981). Effects of cooperative, competitive, and individualistic goal structures on achievement: A meta-analysis. *Psychological Bulletin, 89*, 47-62.

Klein, J.D. Erchul, J.A. & Pridemore, D.R. (1993). Effects of cooperative learning and incentive on motivation and performance. Paper present at the annual meeting of the Association for Educational Communications and Technology, New Orleans,

Noell, J. & Carnine, D. (1989). Group and individual computer-based video instruction. *Educational Technology*, 29(1), 36-37.

Rysavy, D.M. & Sales, G.C. (1991). Cooperative learning in computer-based instruction. *Educational Technology Research and Development, 39* (2), 70-79.

Simsek, A. & Tsai, B. (1992). The impact of cooperative group composition on student performance and attitudes during interactive videodisc instruction. *Journal of Computer-Based Instruction, 19* (3), 86-91.

Slavin,R.E. (1991). Research on cooperative learning: Consensus and controversy. *Educational Leadership, 47*(4), 52-54.

Tudge, J. (1991). Age and gender as moderators of the effects of peer collaboration. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Hypermedia

Ambrose, D.W. (1991). The effects of hypermedia on learning: A literature review. *Educational Technology, 30*(12), 51-55.

Bowers, D. & Tsai, C. (1990). Hypercard in educational esearch: An introduction and case study. *Educational Technology, 29*(2), 19-24.

Carver, S.M., Lehrer, R., Connell, T. & Erickson, J. (1992). Learning by hypercard design: Issues of assessment and implementation. *Educational Psychologist, 27*(3), 385-404.

Gay, G. & Mazur, J. (1989). Conceptualizing a hypermedia design for language learning. *Journal of Research and Computing in Education, 22*(4), 119-126.

Heller, R.S. (1990). The role of hypermedia in education; A look at the research issues. *Journal of Research on Computing in Education, 22*(2), 431-441.

Kinzie, M.B. & Berdel, R.L. (1989). Design and use of hypermeida systems. *Educational Technology Research and Development, 38* (3), 61-68.

Nelson, W. A. & Joyner, O.J. (1990). Effects of document complexity and organization on learning from hypertext. Paper presented at the annual meeting of the Eastern Educational Research Association, Clearwater, FL.

Nelson, W. A. & Palumbo, D. B. (1992). Learning, instruction, and hypermedia. *Journal of Educational Multimedia and Hypermedia, 1*(3), 287-299.

Park, Ok-choon (1991). Hypermedia: Functional features and research issues. *Educational Technology, 30*(8), 24-31.

Picher, O. (1991). Hypermedia. In E. Berk & J. Devlin (Eds.), *Hypertext/Hypermedia Handbook*, (pp.17-22), New York: McGraw Hill.

Small, R.V. & Grabowski, B.L. (1992). An exploratory study of information-seeking behaviors and learning with hypermedia information systems. *Journal of Educational Multimedia and Hypermedia, 1*(4), 455-464.

Tsai, C. (1988). Hypertext: Technology, applications, and research issues. *Journal of Educational Technology Systems, 17*(1), 3-14.

Hypertext

Berk, E. (1991). Types of hypertexts. In E. Berk & J. Devlin (Eds.), *Hypertext/Hypermedia Handbook*, (pp.17-22), New York: McGraw Hill.

Binder, C. (1989). Hypertext design issues. *Performance Improvement Quarterly, 2*(3), 16-33.

Conklin, J. (1987). Hypertext: An introduction and survey. *Computer,20*(9), 12-41.

Cook, D. (1991). Lost (and found) in hyperspace. *CBT Directions, 4*(7), 10-17.

Gillingham, M.G. (1992). Goal-directed reading of complex embedded hypertexts: Effects of goal and interest on search strategies and selective attention. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Jonassen, D.H. (1989). *Hypertext/hypermedia*. Englewood Cliffs, NJ: Educational Technology Publications.

Jonassen, D. H. & Wang, S. (1992). Acquiring structural knowledge from semantically structured hypertext. Washington, DC. Association for Educational Communications and Technology. (ERIC Document Reproduction Service No. IR 015 706).

Lambiotte, J.G, Dansereau, D.F., Cross, D.R. & Reynolds, S.B. (1989). Multi-relational semantic maps. *Educational Psychology Review, 1*, 331-367. *Handbook*, (pp.17-22), New York: McGraw Hill.

Stanton, N.A., Taylor, R. G. & Tweedie, L.A. (1992). Maps as navigational aids in hypertext environments: An empirical evaluation. *Journal of Educational Multimedia and Hypermedia. 1*(1), 431-444.

Nielsen, J. (1990). *Hypertext and hypermedia.* Boston: Harcourt Brace Javanovich.

Reynolds, S.B. & Dansereau, D.F. (1990). The knowledge hypermap: An alternative to hypertext. *Computers Educ, 14*(5), 409-416.

Instructional Strategies

Cognition and Technology Group at Vanderbilt (1992a). The Jasper experience: An exploration of issues in learning and instructional design. *Educational Technology Research and Development, 40* (1), 65-80.

Cognition and Technology Group at Vanderbilt (1992b). The Jasper series as an example of anchored instruction: Theory, program description, and assessment data. *Educational Psychologist, 27*(3), 291-315.

Gay, G. (1991). Structuring interactive multimedia fiction. In E. Berk and J. Devlin (Eds.) *Hypermedia/Hypertext Handbook* (pp.165-178) .New York: McGraw-Hill.

Litchfield, B.C. and Mattson, S.A. (1989). The interactive media science project: An inquiry-based multimedia science curriculum. *Journal of Computers in Mathematics and Science Teaching*, 9 (1), 37-43.

Sherwood, R. D., Kinzer, C. K. & Carrick, D. The use of videodisc-based technology to develop contextually rich instruction in science. Paper presented at the annual meting of the National Association for Research in Science Teaching, Washington, DC.

Tobin, K. & Dawson, G. (1992). Constraints to curriculum reform: Teachers and the myths of schooling. *Educational Technology Research and Development, 40* (1), 81-92.

Wilson, K. (1987). The Palenque optical disc prototype: Development of an exploratory learning environment for children. Paper presented at the annual meeting of the American Educational Research Association, Washington, DC.

Wilson, K. (1991). Storytelling for better CBT. *CBT Directions, 4*(6), 10.

Interactive Video

Barba, R. H. & Armstrong, B.E. (1992). The effect of hypercard and interactive video instruction on earth and space science students' achievement. *Journal of Educational Multimedia and Hypermedia, 1*(3), 323-330.

Burwell, L. (1991). The interaction of learning styles with learner control treatments in an interactive videodisc lesson. *Educational Technology, 31*(3), 37-43.

Cronin, M.W. & Cronin, K.A. (1992). A critical analysis of the theoretic foundation of interactive instruction. *Journal of Computer-Based Instruction, 19*(2), 37-41.

Fletcher, J.D. (1990). Effects and cost of IVD instruction in defense training and education. IDA P-2372) Alexandria,VA: Institute for Defense Analysis.

Hannafin, M. J. , Phillips, T.L. & Tripp, S.D. (1986). The effects of orienting, processing, and practicing activities on learning from interactive video.*Journal of Computer-Based Instruction, 13*(4), 134-139.

Litchfield, B.C. (1993). Feedback and certitude in interactive videodisc programs. In J.V. Dempsey and G.Sales (Eds.) *Feedback in Interactive Instruction.* Englewood Cliffs, NJ: Educational Technology Publications.

Litchfield, B.C. (1990). Criteria for evaluating videodisc interactivity. *Performance and Instruction, 29*(6), 23-26.

Litchfield, B.C. (1992) Component Design for Interactive Videodisc Projects. Proceedings for the International Conference on Technology in Education. Paris, France.

Locatis, C., Charuhas, J. & Banvard, R. (1990). Hypervideo. *Educational Technology Research and Development, 32* (2), 41-49.

McNeil, B.J. & Nelson, K.R. (1991). Meta-analysis of interactive video instruction: A 10 year review of achievement results. *Journal of Computer-Based Instruction, 18*(1), 1-6.

Learner Control

Arnone, M.P. & Grabowski, B.L. (1992). Effect on children's achievement and curiosity of variations in learner control over an interactive video lesson. *Educational Technology Research and Development, 40* (1), 15-27.

Azbell, J.W. & Milheim, W. D. (1988). How past research on learner control can aid in the design of interactive video materials. Paper presented at the annual meeting of the Association for Educational Communications and Technology, New Orleans.

Barnard, J. (1992). Video-based instruction: Issues of effectiveness, interaction, and learner control. *Journal of Educational Technology Systems, 21* (1), 45-50.

Cooper, R. (1991). The debate over learner control. *CBT Directions, 4* (4), 18- 23.

Friend C.L. & Cole, C.L. (1990). Learner control in computer-based instruction: A current literature review. *Educational Technology , 29* (11), 47-49.

Gery, G. (1989). The learner can now be in control. *Instruction Delivery Systems, 3*(2), 6-9.

Johansen, K.L. & Tennyson, R. D. (1983). Effect of adaptive advisement on perception in learner-controlled, computer-based instruction using a rule using task. *Educational Communications and Technology Journal, 31* (4), 226-236.

Kinzie, M.B. & Sullivan, H.J. (1989). Continuing motivation, learner control, and CAI. *Educational Technology Research and Development, 37*(2), 5-14.

Lanza, A. & Roselli, T. (1991). Effects of the hypertextual approach versus the structured approach on students' achievement. *Journal of Computer-Based Instruction, 18* (2), 48-50.

Morrison, G. R., Ross, S.M.,& Baldwin, W. (1991). Learner control of context and instructional support in learning elementary school mathematics. *Educational Technology Research and Development, 40* (1), 5-13.

Murphy, M. A. & Davidson, G.V. (1991). Computer-based adaptive instruction: Effects of learner control on concept learning. *Journal of Computer-Based Instruction, 18* (2), 51-56.

Okey, J.R. & Jones, M.G. (1990). Learner decisions and information requirements in computer-based instruction. Paper presented at the annual meeting of the International Conference of the Association for the Development of Computer-Based Instruction, San Diego.

Ross, S.M. & Morrison, G. R. (1988). Adapting instruction to learner performance and background variables. in D.H. Jonassen (Ed.), *Instructional designs for microcomputer courseware* (pp.227-245).Hillsdale, NJ: Lawrence Erlbaum.

Ross, S.M. & Morrison, G. R. (1988). In search of a happy medium in instructional technology research: Issues concerning external validity, media replications, and learner control. *Educational Technology Research and Development, 37* (1), 19-33.

Santiago, R.S. & Okey, J.R. (1992). The effects of advisement and locus of control on achievement in learner-controlled instruction. *Journal of Computer-Based Instruction, 19* (2), 47-53.

Learning Styles

Carlson, H.L. (1991). Learning styles and program design in interactive multimedia. *Educational Technology Research and Development, 39*(3), 41-48.

Cordell, B.J. (1991). A study of learning styles and computer-assisted instruction. *Computers Educ. 16* (2), 175-183

Davidson, G.V., Savenye, W.C. & Orr, K.B. (1992). How do learning styles relate to performance in a computer applications course? *Journal of Research on Computing in Education, 24* (3), 315-328.

Dunn, K.J. & Dunn, R.S. (1978). *Teaching students through their individual learning styles.* Reston , VA: Reston Publishing.

Gregorc, A.F. (1984). *Gregorc style delineator: Development technical and administration manual.* Columbia, CT: Gregorc Associates, Inc.

Kolb, D.A. (1981).Learning styles and disciplinary differences. In Chickering, A.M. (Ed.), *The Modern American College.* San Francisco: Jossey Bass.

McCarthy, B. (1980). *The 4MAT system.* Oak Brook, IL:Excel, Inc.

Yung, B. & Lee, B. (1992). Effects of learning style in a hypermedia instructional system. Washington, DC. Association for Educational Communications and Technology. (ERIC Document Reproduction Service No. IR 015 706).

Navigation

Dempsey, J.V. (1986). Using the rational set generator with computer-based instruction for creating concept examples:A template for instructors.Educational Technology, 26 (4), 43-46.

Driscoll, M.P., & Tessmer, M. (1985). The rational set generator: A method for creating and testing concept examples for teaching and testing. Educational Technology, 25 (2), 29-32.

Jih, H.J. & Reeves T.C. (1992). Mental models: A research focus for interactive learning systems. *Educational Technology Research ad Development, 40* (3), 39-53.

Marquez, M.E. & Lehman, J.D. (1992). Hypermedia user-interface design: The role of individual differences in placement of icon buttons. *Journal of Educational Multimedia and Hypermedia, 1* (4), 417-429.

Mueller, N.S. (1991). Face to interface. *CBT Directions, 4* (4), 31-33.

Reynolds, S.B., Patterson, M.E., Skaggs, L.P. & Dansereau, D.F. (1991). Knowledge maps and cooperative learning. *Computers Educ, 16* (2), 167-173.

Schuerman, R. L. & Peck, K.L. (1991). Pull-down menus, menu design, and usage patterns in computer-assisted instruction. *Journal of Computer-Based Instruction, 18* (3), 93-98.

Stanton, N.A.,Taylor, R.G. & Tweedie, L.A. (1992). Maps as navigational aids in hypertext environments: An empirical evaluation. *Journal of Educational Multimedia and Hypermedia, 1* (4), 431-444.

Trumbull, D., Gay, G. & Mazur, J. (1991). Students' actual and perceived use of navigational and guidance tools in a hypermedia program. *Journal of Research on Computing in Education, 24* (3), 315-328.

Venezky, R. & Osin, L. (1991). *The intelligent design of computer-assisted instruction.* New York: Longman.

Motivation

Flagg, B.N. (1990). *Formative evaluation for educational technologies.*Hillsdale, NJ: Lawrence Erlbaum Associates.

Gray, S.H. (1987). Effect of sequence control in computer-assisted learning. *Journal of Computer-Based Instruction, 15*(3), 57-60.

Keller, J.M. (1983). Motivational design of instruction. In C.M. Reigeluth (Ed.), *Instructional design theories and models: An overview of their current status.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Keller, J. & Burkman, E. (1993). Motivation principles. In M. Fleming and W. Levie (Eds.) *Instructional Message Design: Principles for the Behavioral and Cognitive Sciences* (pp.3-53), Englewood Cliffs, NJ: Educational Technology Publications.

Keller. J. M. & Suzuki, K. (1988). Use of the ARCS motivation model in courseware design. In D. H. Jonassen (Ed.), *Instructional designs for microcomputer courseware.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Kinzie, M.B. (1991). Requirements and benefits of effective interactive instruction: Learner control, self-regulation, and continuing motivation. *Educational Technology Research and Development, 38* (1), 1-21.

Other

Bush, V. (1945). As we may think. *Atlantic Monthly, 176*(1), 101-108.

Devlin, J. (1991). Standards for hypertext. In E. Berk and J. Devlin (Eds.) *Hypermedia/Hypertext Handbook* (pp.1437-444.) .New York: McGraw-Hill.

Gayeski, D.M. (1993). *Multimedia for learning.* Englewood Cliffs, NJ: Educational Technology Publications.

Hannafin, M.J. & Hooper. S. R. (1993). Learning principles. In M. Fleming and W. Levie (Eds.) *Instructional Message Design: Principles for the Behavioral and Cognitive Sciences* (pp.191-231), Englewood Cliffs, NJ: Educational Technology Publications.

Jonassen, D. (1988). *Instructional design for microcomputer courseware.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Litchfield, B.C. & Dempsey, J.V. (1991-92). Seven-stage quality control model for interactive videodisc projects.*Journal of Educational Technology Systems.* 20(2), 129-132.

Nelson, T.H. (1967). Getting it out of our system. In G. Schecter (Ed.) *Information retrieval: A critical review. Washington: Thompson Books, 191-210.*

Reeves, T.C. (1993). Evaluating Interactive multimedia. In D.M. Gayeski, (Ed.) *Multimedia for Learning* (pp.97-112).Englewood Cliffs, NJ: Educational Technology Publications.

Table 1
Summary of citations for each design factor.

Factor	Author	Topic
INSTRUCTIONAL		
Instructional Strategies	Cognition and Technology Group - Vanderbilt (1992)	Anchored instruction in an IVD math program
	Gay, (1991)	Structuring interactive multimedia fiction
	Litchfield & Mattson (1989)	Inquiry-based multimedia science curriculum
	Sherwood, Kinzer & Carrick (1987)	Anchored instruction in science using video context
	Tobin & Dawson (1992)	Problem solving in science with IVD
	Wilson (1987)	Exploratory learning environment with IVD
	Wilson (1991)	Dramatic scenarios /analogous situations for CBT
Cooperative Learning	Hoelscher (1990)	Cooperative learning with law students
	Hooper (1992)	Design factors for cooperative learning CBI programs
	Johnson & Johnson (1986)	Computer-assisted cooperative learning
	Johnson, Maruyama, Johnson, Nelson & Skon (1981)	Meta-analysis of cooperative learning
	Klein, Erchul, & Pridemore (1993)	Cooperaive learning and incentives on motivation
	Noell & Canine (1989)	Group and individual computer-based video instruction
	Rysavy & Sales (1991)	Achievement,study patterns,motivation,gender
	Simsek & Tsai (1992)	Group composition on performance and attitudes with IVD
	Slavin (1991).	Synthesis of research on cooperative learning
	Tudge (1991)	Age and gender as moderators in peer collaboration
AFFECTIVE		
Learning Styles	Carlson (1991)	Learning styles and program design in interactive multimedia
	Cordell (1991)	Learning styles and CAI
	Davidson, Savenye & Orr (1992)	Learning styles and performance-computer applications course
	Dunn & Dunn (1978)	Theory
	Gregorc (1984)	Style inventory
	Kolb (1981)	Learning styles and disciplinary differences
	McCarthy (1980)	Theory
	Yung & Lee (1992)	Learning style in a hypermedia instructional system
Motivation	Flagg (1990)	Formative evaluation for educational technologies
	Gray (1987)	Sequence contol in computer-assisted learning
	Keller (1983)	ARCS motivation model
	Keller & Burkman (1993)	Motivation principles
	Keller & Suzuki (1988)	ARCS motivation model in courseware design
	Kinzie (1989)	Learner control, self-regulation, and continuing motivation
BRANCHING		
Navigation	Dempsey (1986)	CBI rational set generator
	Driscoll & Tessmer (1985)	Rational set generator
	Jih & Reeves (1992)	Mental models for interactive learning systems
	Marquez& Lehman (1992)	Individual differences in placement of icon buttons
	Mueller (1991)	Interface considerations
	Reynolds, Patterson, Skaggs & Dansereau (1991)	Knowledge maps and cooperative learning
	Schuerman & Peck (1991)	Pull-down menus/menu design/usage patterns in CAI
	Stanton, Taylor, & Tweedie (1992)	Maps as navigational aids in hypertext environments
	Trumbull, Gay & Mazur (1991)	Actual/perceived use of navigational and guidance tools
	Venezky & Osin (1991)	Design of CBI
Learner Control	Arnone & Grabowski (1992)	Achievement and curiosity in IVD
	Azbell & Milheim (1988)	Research on learner control and the design of IVD
	Barnard (1992)	Effectiveness, interaction, and learner control
	Cooper (1991)	Debate over learner control
	Friend & Cole (1990)	Literature review

	Gery (1989)	Learner control issues
	Johansen & Tennyson (1983)	Adaptive advisement on perception in learner-controlled CAI
	Kinzie & Sullivan (1989)	Motivation, learner control and CAI
	Lanza & Roselli (1991)	Control of structured vs. hypertext system
	Morrison, Ross,& Baldwin(1991)	Context and instructional support
	Murphy & Davidson, (1991).	Concept learning
	Okey& Jones (1990)	Learner decisions and information requirements
	Ross & Morrison(1988a)	Learner performance and background variables
	Ross & Morrison (1988b)	External validity, media replications, and learner control
	Santiago & Okey (1992)	Advisement and locus of control on achievement
MEDIA		
Interactive Video	Barba & Armstong(1992)	Hypercard and IVD on achievement
	Burwell (1991)	Learning styles and learner control
	Cronin & Cronin (1992)	Theoretic foundation of IVD
	Fletcher (1990)	Meta-analysis of cost and effectiveness
	Hannafin, Phillips & Tripp (1986)	Orienting/processing/practicing activities
	Litchfield (1990)	Evaluating interactivity of IVD programs
	Litchfield (1992)	Component Design for IVD
	Litchfield (1993)	Feedback in interactive technologies
	Locatis, Charuhas & Banvard (1990)	Hypervideo
	McNeil & Nelson (1991)	Meta-analysis of IVD effectivness
Hypertext	Berk (1991)	Types of hypertexts
	Binder (1989)	Hypertext design issues
	Conklin (1987)	Introduction and survey
	Cook (1991)	Lost (and found) in hyperspace
	Gillingham (1992)	Search strategies/selective attention with embedded hypertexts
	Nelson & Joyner (1990)	Hypertext document complexity and organization
	Nielsen (1990)	Hypertext and hypermedia text
	Jonassen & Wang (1992)	Structural knowledge from semantically structured hypertext
	Lambiotte, Dansereau, Cross & Reynolds (1989)	Multi-relational semantic maps
	Reynolds & Dansereau (1990).	Hypermap vs. hypertext
	Stanton, Taylor & Tweedie (1992)	Maps as navigational aids
Hypermedia	Ambrose (1991).	Hypermedia and learning literature review
	Bowers & Tsai (1990)	Case study using Hypercard
	Gay & Mazur (1989)	Hypermedia design for language learning
	Heller(1990)	Hypermedia in education- research issues
	Kinzie & Berdel (1989)	Design and use of hypermeida systems
	Nelson & Palumbo (1992)	Learning, instruction, and hypermedia
	Picher (1991)	Hypermedia
	Park (1991)	Functional features and research issues
	Small & Grabowski (1992)	Information-seeking behaviors using hypermedia
	Tsai (1988)	Technology, applications, and research issues